Irene Papst is Senior Advisor at HEAT GmbH and has more than 10 years of experience in advising the transformation of the refrigeration and air conditioning sector at all stages of ODS and HFC use: manufacture, service and decommissioning.

As a modeling specialist, she estimated global ODS and HFC banks and waste streams on a per country-level to provide a starting point for national considerations of ODS banks management. Irene is experienced in the monitoring, review and verification of emissions abatements of mitigation projects, including several projects on abatement of F-gas emissions.

Ms. Irene Papst

Senior Advisor – HEAT GmbH

Mr. Kevin Carl is a researcher at RWTH Aachen University at the Department of Technology of Fuels. He is working directly under Prof. Quicker as chief engineer of the institute. His main focus of research is on thermal waste treatment and (halogen-) organic pollutants.

He is involved in the planning and commissioning of several incineration plants as well as biomass power plants. He is currently an expert for the consulting from HEAT, which is specializing in environmentally friendly refrigeration and air conditioning equipment as well as the safe management and disposal of ozone depleting substances. In this role he is assessing a rotary kiln in Ghana for the environmentally safe processing of ODS.

Mr. Kevin Carl

RWTH Aachen University

WEBINAR SERIES

CLOSING THE LOOP: ENVIRONMENTALLY SOUND MANAGEMENT OF END-OF-LIFE ODS AND HFC

Destruction options for ODS/HFC foam – Overview and experiences from the EU and Ghana

Irene Papst - HEAT GmbH
Kevin Carl – RWTH Aachen

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This webinar is being organized within the framework of a project funded by US EPA

EPA United States Environmental Protection Agency

The ODS Banks Project

- Funded by the German Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMU) within the framework of the International Climate Initiative (IKI)
- Project duration: November 2013 – June 2021
- Global project, with 5 partner countries: Colombia, Dominican Republic, Ghana, Iran and Tunisia
- Partner institutions: ministries of environment/ industry/ technology and their national ozone units
- Stakeholders: ministries, public institutions, private sector, NGOs, technology supplier, consumers

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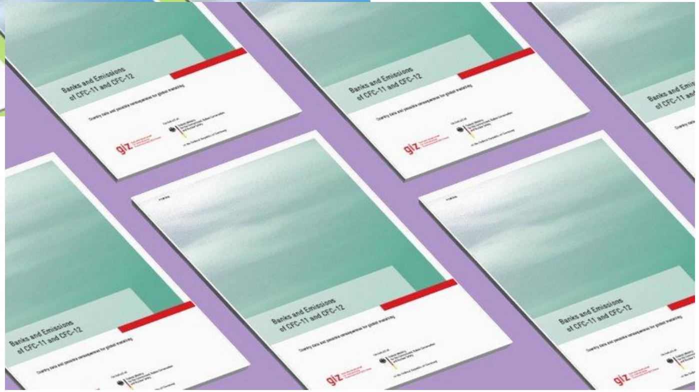
On behalf of:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany

ODS Banks – Publications



- Global Roadmap (2017): here
- Inventory Guideline (#1, 2017): here
- Policy Measures (#2, 2017): here
- Collection Systems (#3, 2017): here
- TBM (#4, 2017): here
- Manual Dismantling (2017): here
- **Thermal Destruction of (H)CFCs and HFCs (2020):** here
- **Banks and Emissions of CFC-11 and CFC-12 (2020):** here

Agenda

- Destruction of foam that contains ODS/HFC blowing agents
- Regulation and practice in selected EU member states
- Activities in Ghana

Relevant foam uses

- Appliance Foam
  - Insulation of refrigerators (new production usually relies on hydrocarbon blowing agent)
- Building foam
  - Polyurethan PU panels
  - Extruded polystyrene (XPS)

Blowing agent content at EOL

- Depends on foam type

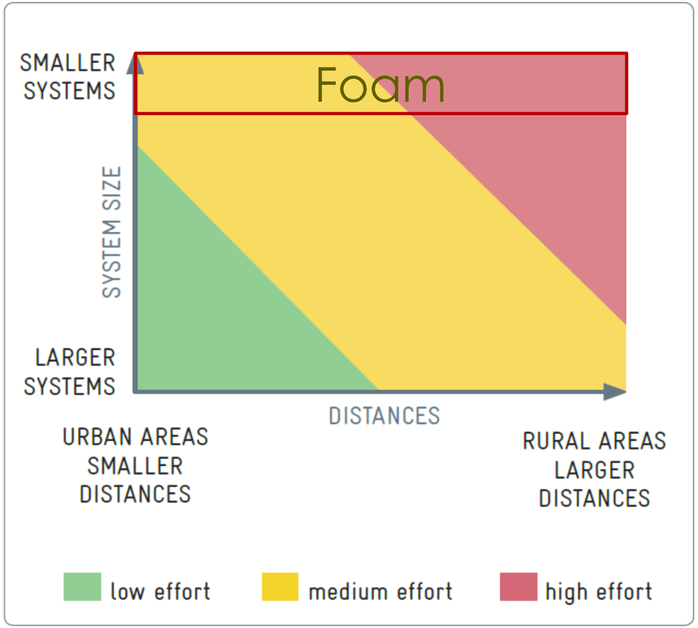
Foam Type	First year release [%]	Release rate [%/year]	Lifetime of foam [years]	Total remaining at decommissioning [%]
PU cont. panel	8.8-11.25%	0.50%	50	63.75-66.5%
PU disc. panel	8.8-11.25%	0.50%	50	63.75-66.5%
PU appliance	4%	0.25%	14	40%
PU disc. block	33%	0.88%	15	54%
PU spray	15%	1.5%	50	10%
XPS board	25%	0.8%	25	56%

Source: EPA Vintage Model (EPA (2019))

Why is foam different?

- ODS/HFC used as blowing agent are used to expand a plastic material to "bubble up" and create a light-weight material with good insulation properties
- This low density, which is favourable during its use, creates problems for destruction, as it results in high volumes for transport

Priorities and technical feasibility

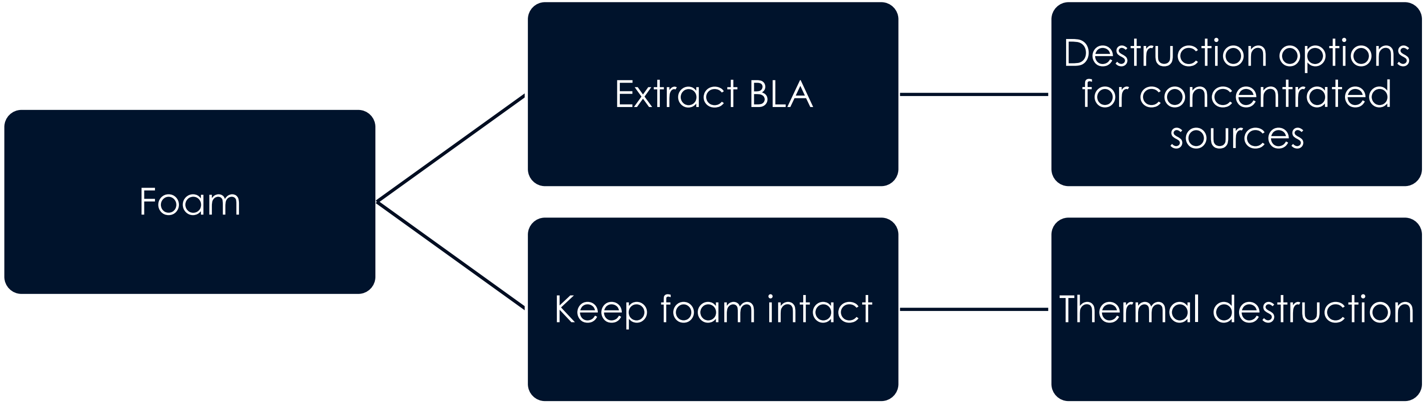


Effort levels: low, medium, high (TEAP 2009)

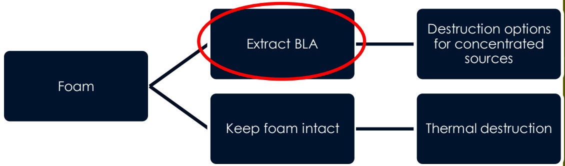
Less effort for recovery when:

- equipment containing larger quantities,
- ODS that is geographically more concentrated, and
- non-diluted ODS (e.g. refrigerant) compared to diluted ODS (such as foams)

Destruction options for foam



Extraction of BLA

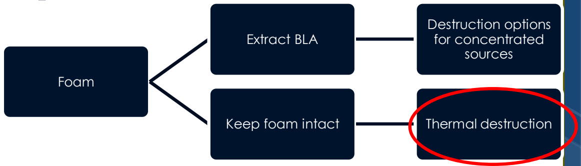


- Shredding of foam in enclosed system to release the BLA from the foam cells
  - Liquifying of ODS/HFC by liquid nitrogen

  or

  - Adsorption of ODS/HFC on activated carbon
  - Charcoal can be shipped to destruction plant, ODS/HFC can be released again by heating up to 120°C – reuse of charcoal is cheaper than combustion with ODS/HFC

Destruction of foam pieces



- Cement kiln
- Municipal waste incineration
- Rotary kiln

- Problem: transport of foam (very low density, typically < 20 kg/m^3)

Cement kiln

- Clinker production requires temperatures between 1400 -1600 °C and residence times easily reach 10 seconds → guarantees the almost total destruction of any organic compound incl. ODS/HFCs
- Destruction products are neutralized by alkaline environment in cement kiln and incorporated into the clinker
- ODS/HFC amounts limited by Cl and F standard for clinker product
- Use of alternative fuel is common

Municipal waste incineration

- Air pollution control system is required (and a complex and expensive part of the plant)
- EU regulations demand combustion temperatures exceeding 850°C
- Test runs have demonstrated that high destruction efficiencies for foam are achieved
- High investment cost

Rotary kiln

- Usually used for hazardous waste incineration
- High temperature achieved by several burners fueled by natural gas, propane, oil or similar
- High investment cost

Practice in Germany

- Law on circular economy* mandates the treatment of foam containing ODS/HFC as hazardous waste, usually in waste incineration facilities
- Building foams
  - Challenge is the separation of foam when demolishing the building
  - If collected, foam is usually treated at municipal solid waste incineration plants
- Appliance foams
  - Refrigerators are treated in fully automated enclosed system, with condensation of ODS/HFC and subsequent destruction

*Kreislaufwirtschaftsgesetz, KrWG, 2012

Practice in Austria

- Building foams
  - Removal of insulation foams that contain ODS/HFC from buildings prior to the demolition of the building is obligatory since 2017*. The foam is to be treated as hazardous waste
  - it is estimated that about 50% of the foam is actually collected treated in municipal waste incineration plants
  - Cost estimates are about 1% of total renovation or destruction cost
- Appliance foams
  - Refrigerators are treated in fully automated enclosed system, with condensation of ODS/HFC and subsequent destruction

*Regulation on the recycling of building materials (Recycling Baustoff-Verordnung)

Destruction options for ODS/HFC foam waste

A showcase in Ghana

Project Stakeholders

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

ZEAL ENVIRONMENTAL TECHNOLOGIES LIMITED

epa

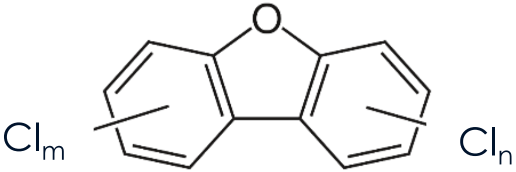
Internat. Consultants:
Prof. Peter Quicker
Kevin Carl

Local Consultant:
Kwaku Oduro-Appiah

Project Objective

- Environmentally sound thermal waste treatment for:
  - Insulation foams containing ODS blowing agents
  - ODS containing refrigerants in liquid/gaseous form

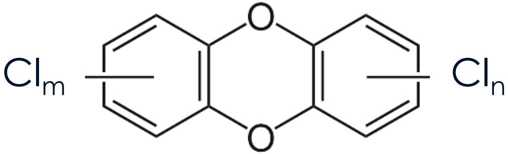
Technical Challenges



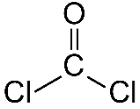
Furans (PCDF)

HF
Hydroflouric acid

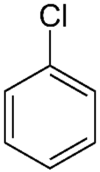
HCl
Hydrochloric acid



Dioxins (PCDD)



Phosgene



Chlorobenzene

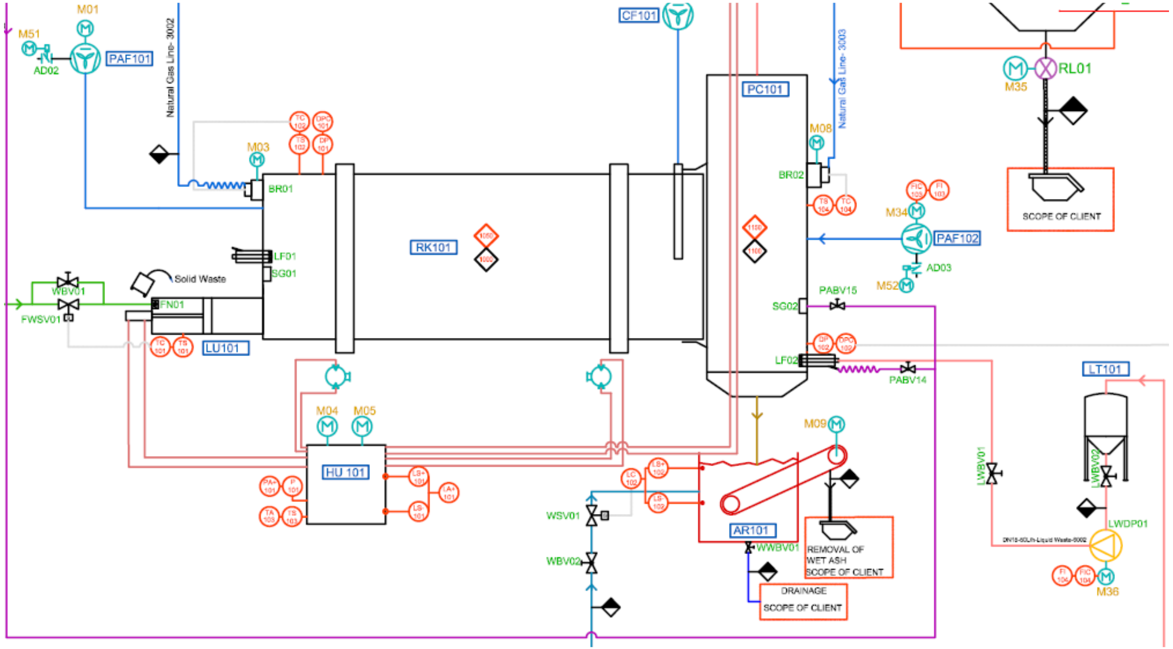
Requirements for the incineration process

- Sufficient **temperature and residence time**
- Compliance with **European environmental standards** with special regard to **air emissions**
- Safe and stable, cost-effective operation

Technical approach: Rotary Kiln Incinerator

Source: Santes Incinerator

Technical approach: Rotary Kiln Incinerator



Source: Santes Incinerator

Technical Specifications

- Fuel input:
  - **1000 kg/h** solid waste, C_{Cl} < 2 %, C_S < 3 % (daf)
  - **100 l/h** liquid waste (injection in afterburning chamber)
- Temperature levels:
  - 1000 °C in rotary kiln
  - 1100 °C for 2 s in afterburning chamber

Gas cleaning system

- Gas cooling via **heat exchanger**
- Removal of **acid components** with lime (dry) and sodium hydroxide solution (wet)
- Removal of **organic pollutants** with active charcoal
- Baghouse filter for **dust (fly ash)** removal

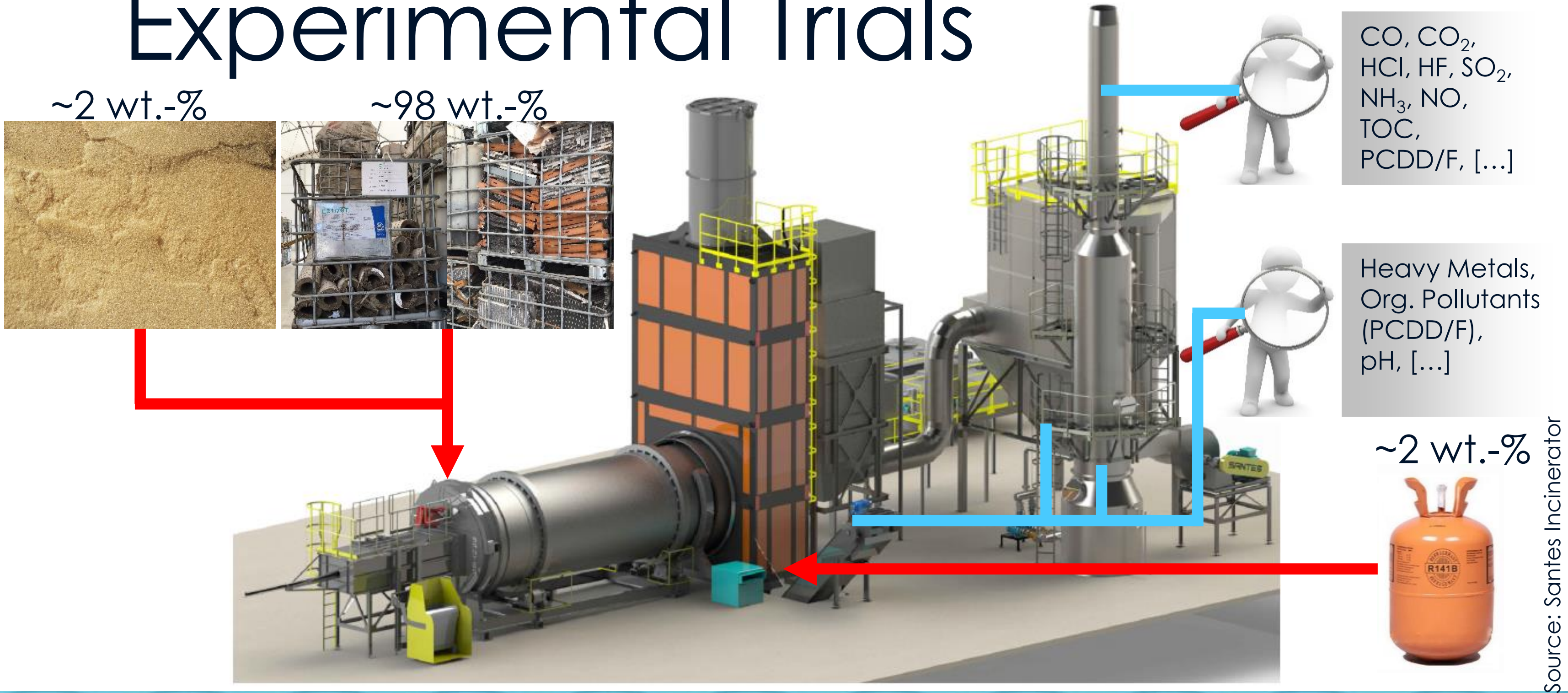
Advantages

- Proven **state-of-the art** technology for hazardous waste treatment
- Minimum amount of **pre-processing** for required
- Foams and refrigerants could be safely destroyed in the same plant

Challenges

- Comparably **high investment and operational costs**
- Proper storage/disposal of the solid and liquid **process residues** (bottom-/fly ash, condensate, used scrubbing liquid)
- Workers health and safety (HSE)

Experimental Trials



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Thanks for your attention

Irene Papst, M.Sc. – HEAT Gmbh
Irene.Papst@heat-international.de

Kevin Carl, M Sc. – Qonversion
kevin.carl@rwth-aachen.de

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